WE CLAIM:

1. An optical communication channel interleaver for operating on an optical signal comprising multiple optical channels having odd and even channel frequencies, the optical communications signal comprising at least one optical beam, the interleaver comprising:

   a first port;

   a second port;

   a third port;

   an echelle grating interleaving unit disposed to diffractively couple light, having even channel frequencies, between the first port and the second port and light, having odd channel frequencies, between the first port and the third port.

2. An interleaver as recited in Claim 1, the echelle grating interleaving unit including an optical coupling system disposed between an echelle grating and the first port and at least one of the second and third ports to couple light between the first port and at least one of the second and third ports, via the echelle grating.

3. An interleaver as recited in Claim 2, wherein the optical coupling system includes a lens array and an optical focusing element.

4. An interleaver as recited in Claim 3, wherein the lens array includes individual focusing elements associated with respective ports.

5. An interleaver as recited in Claim 4, wherein the individual focusing elements in the lens array are positioned to couple light in the ports to substantially collimated beams.

6. An interleaver as recited in Claim 3, wherein the echelle grating includes a transparent substrate and light propagating between the first port and at least one of the second and third ports passes through the substrate.

7. An interleaver as recited in Claim 2. wherein the optical coupling system includes a faceted beam steering element and an optical focusing element.

8. An interleaver as recited in Claim 6, wherein the echelle grating includes a transparent substrate and the light passes through the substrate.

9. An interleaver as recited in Claim 8, wherein the faceted beam steering element is attached to the substrate.

10. An interleaver as recited in Claim 8, wherein the faceted beam steering element is integrally formed with the substrate.

11. An interleaver as recited in Claim 2, wherein the echelle grating has a reflective diffractive surface.

12. An interleaver as recited in Claim 1, the echelle grating interleaving unit including a first optical coupling system disposed between the first port and the echelle grating and a second optical coupling system disposed between the grating and at least one of the second and third ports, the first and second optical coupling systems coupling light propagating between the first and at least one of the second and third ports, via the echelle grating.

13. An interleaver as recited in Claim 12, wherein the first optical coupling system is a lens.

14. An interleaver as recited in Claim 12, wherein the second optical coupling system includes a lens array and an optical focusing element.

15. An interleaver as recited in Claim 14, wherein the lens array includes individual focusing elements associated with the second and third ports.

16. An interleaver as recited in Claim 15, wherein the individual focusing elements in the lens array are positioned to couple light in the second and third ports to substantially collimated beams.

17. An interleaver as recited in Claim 12, wherein the echelle grating includes a transparent substrate and the light coupled between the first port and at least one of the second and third ports passes through the substrate.

18. An interleaver as recited in Claim 17 wherein the second optical coupling system includes a faceted beam steering element and an optical focusing element.

19. An interleaver as recited in Claim 18, wherein the faceted beam steering element is attached to the substrate.

20. An interleaver as recited in Claim 18, wherein the faceted beam steering element is integrally formed with the substrate.

21. An interleaver as recited in Claim 17, wherein the echelle grating is oriented with a diffractive surface nearest the first port.

22. An interleaver as recited in Claim 17, wherein the echelle grating is oriented with a diffractive surface nearest the second and third ports.

23. An interleaver as recited in Claim 1, wherein the even-channel light is diffracted in a first direction and the odd-channel light is diffracted in a second direction different from the first direction.

24. An interleaver as recited in Claim 23, wherein the first direction and the second direction form an angle at the echelle grating that is bisected by an optical axis.

25. An interleaver as recited in Claim 23, wherein light coupled to the first port propagates in a direction that is parallel to the optical axis at the grating.

26. An interleaver as recited in Claim 1, wherein different even channels are diffracted in respectively different diffractive orders.

27. An interleaver as recited in Claim 26, wherein different odd channels are diffracted in respectively different diffractive orders.

28. An optical fiber communications system, comprising:

an optical transmitter unit generating light in multiple optical channels having channel frequencies of $\nu_o + m\Delta\nu$ where ν_o is the lowest frequency,

$\Delta\nu$ is the channel separation, and m is an integer;

an optical detector unit detecting signals of the multiple optical channels; and

an optical communications network coupled between the optical transmitter unit and the optical detector unit, the optical communications network including at least one optical fiber;

wherein at least one of the optical transmitter unit and the optical detector unit includes an optical interleaver coupled to the optical communications network, the optical interleaver comprising

a first port;

a second port;

a third port;

an echelle grating interleaving unit disposed to diffractively couple light, having even channel frequencies, between the first port and the second port and light, having odd channel frequencies, between the first port and the third port, the interleaver coupled to the optical communications network by the first port and at least one of the second and third ports.

29. An optical fiber communications system as recited in Claim 28, further comprising at least one optical amplifier disposed in at least one of the optical transmitter unit, the optical network and the optical detector unit.

30. An optical fiber communications system as recited in Claim 28, wherein the first port is coupled to receive multi-channel light from the optical transmitter

unit and at least one of the second and third ports is coupled to transmit an output light beam for detection within the optical detection unit.

31. A system as recited in Claim 30, wherein the optical detector unit includes a plurality of optical detectors for detecting light having different channel frequencies and at least one wavelength division demultiplexing element disposed between at least one of the second port and the third port and the plurality of optical detectors to direct light from the interleaver to the plurality of optical detectors.

32. A system as recited in Claim 28, wherein the second port is coupled to receive light from an even-channel transmitter, the third port is coupled receive light from an odd-channel transmitter, and the first port is coupled to transmit a multi-channel light beam.

33. A system as recited in Claim 32, wherein at least one of the even channel transmitter and the odd channel transmitter includes a plurality of light sources to generate light beams at the optical channel frequencies and at least one wavelength division multiplexing element being coupled between the plurality of light sources and the interleaver to direct at least two beams to the interleaver.

34. A system as recited in Claim 28, wherein light having different even channel frequencies is diffracted by the echelle grating interleaving unit in respectively different diffraction orders.

35. A system as recited in Claim 34; wherein light having different odd channel frequencies is diffracted by the echelle grating interleaving unit in respectively different diffraction orders.

36. A method for de-interleaving an input light beam having a plurality of channel frequencies uniformly spaced by a frequency difference, comprising:

directing the input light beam to an echelle grating;

diffracting with the echelle grating odd channel frequencies in a first beam at a first angle to the input light beam and even channel frequencies in a second beam at a second angle to the light beam, the second angle different from the first angle; and

selecting at least one of the odd and even beams as an output beam.

37. A method as recited in Claim 36, wherein the echelle grating is a transmission grating.

38. A method as recited in Claim 36, including passing at least one of the input beam, the first beam, and the second beam propagates through a grating substrate.

39. A method as recited in Claim 36, wherein the grating is a reflection grating.

40. A method as recited in Claim 36, including coupling the input beam to a first port, the first beam to a second port, and the second beam to a third port with an optical focusing system.

41. A method as recited in Claim 36, including coupling the input beam to a first port with a first optical focusing system and coupling, with a second optical system, the first beam to a second port and the second beam to a third port.

42. A method as recited in Claim 36 including bending the first beam and the second beam with a faceted beam steering element.

43. A method as recited in Claim 36, wherein light in the first beam at different odd channel frequencies is diffracted by the echelle grating into respectively different diffraction orders.

44. A method as recited in Claim 36, wherein light in the first beam at different even channel frequencies is diffracted by the echelle grating into respectively different diffraction orders.

45. A method for interleaving a first beam with odd channel frequencies and a second beam with even channel frequencies to form an output light beam having odd and even channel frequencies uniformly spaced by a frequency difference, comprising:

directing the first beam to an echelle grating at a first angle to a grating surface normal;

directing the second beam to the echelle grating at a second angle to the grating surface normal, the second angle being different from the first angle;

diffractively coupling the first beam and the second beam via the echelle grating to an output beam.

46. A method as recited in Claim 45, including propagating at least one of the first beam, the second beam and the output beam through a grating substrate.

47. A method as recited in Claim 45, wherein the echelle grating is a transmission grating.

48. A method as recited in Claim 45, wherein the echelle grating is a reflection grating.

49. A method as recited in Claim 45, including coupling the output beam to a first port, the first beam to a second port and the second beam to a third port with an optical focusing system.

50. A method as recited in Claim 45, including coupling the output beam to a first port with a first optical focusing system and coupling, with a second optical system, the first beam to a second port and the second beam to a third port.

51. A method as recited in Claim 45, including bending the first beam and the second beam with a faceted beam steering element.